Dynamical Evolution of Dust Particles in the Kuiper Disk

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Abstract

There is a possible connection between structure in evolved circumstellar disks and the presence of planets, our own zodiacal cloud being a proven example. Asymmetries in such a disk could be diagnostic of planets which would be otherwise undetectable. A Kuiper dust disk will have a resonant structure, with two concentrations in brightness along the ecliptic longitude arising because 10-15% of the Kuiper belt objects, the Plutinos, are in the 3:2 mean motion resonance with Neptune. In our quest to ultimately develop a dynamical model of the Kuiper disk, we run numerical integrations of particles originating from source bodies trapped in the 3:2 resonance and we determine what percentage of particles remain in the resonance for a variety of particle and source body sizes. Because the shape of the particles is not known, the variable we use to denote particle size is β, the ratio of the force of radiation pressure to the force of gravity. The dynamical evolution of the particles is followed from source to sink with Poynting-Robertson light drag, solar wind drag, radiation pressure, the Lorentz force, neutral interstellar gas drag, and the effects of planetary gravitational perturbations included. We find that the number of particles in the 3:2 mean motion resonance increases with decreasing β (i.e., increasing particle size). Consequently, a size frequency distribution for a Plutino disk must be weighted toward larger particles (i.e., those with smaller βs). In addition, as long as the potential, U, of the particles is small ($U \approx 5V$), the Lorentz force does not prevent the particles from remaining in resonance. Similarly, the addition of the effect of neutral interstellar gas drag does not significantly change the percentage of particles remaining in resonance.